Typhlorhynchus nanus: a New Rhabdocœle.

By

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With Plate 35.

The small Rhabdocœle described below was found by Mr. Goodrich at Naples, living on the body of the Polychæte worm Nephthys scolopendroides, Delle Chiaje. He sent a number of specimens preserved with Lang's reagent to Dr. Gamble, who was good enough to hand them over to me for examination. I am indebted to Mr. Goodrich for a further series of specimens, some fixed with corrosive sublimate and acetic acid, others with Lang's reagent; also for figs. 2, 6 *a*, *b*, drawn from life. I have, unfortunately, been unable to study living specimens; hence my account, especially as regards the genital organs, is necessarily somewhat incomplete. The work was done in the Zoological Laboratory at Owens College.

The external appearance and general characters are shown in Pl. 35, fig. 1.

The total length of the body varies from ·7 mm. to 1 mm. In size, therefore, it is quite comparable to a large infusorian such as Stentor polymorphus, Mull. The variations in length between different specimens depend largely on the amount of extension or contraction of the body, especially of that part of it constricted off to form the snout or proboscis.

The body is spindle-shaped (see Pl. 35, fig. 1), the anterior end more pointed than the posterior. The front fifth of the

body is constricted off to form a kind of proboscis or pre-oral lobe (*Pr.*), which is non-retractile. Immediately behind this constriction lies the "mouth" mid-ventrally (*M.*). There are two genital openings, also mid-ventral, lying close together at about a fifth of the total length of the body from its hinder end; the male opening (♂) is in front of the female (♀).

The surface of body is evenly ciliated throughout. In some cases there is a disc-like flattening at the hinder end, but this is only exceptionally present. On the sides of the proboscis are papillæ which resemble in appearance those figured by von Graff for Proxenetes tuberculatus, v. Gr. [2]; a few of these papillæ are present at the hinder end of the body.

The mouth leads through a well-developed pharynx (*Ph.*) into the spacious gut cavity (*En.*), which sends forward a median diverticulum (*A. d.*) into the proboscis, terminating immediately behind the brain (*Br.*), which lies at about the middle of the proboscis. On either side of this anterior diverticulum lies a rounded testis (*Te.*). There is a well-developed penis provided with a complicated armature (*Pe.*) lying in front of the male opening. Into the penis open a pair of vesiculæ seminales (*V.s.*) and a number of unicellular glands (*Gl.*). The female aperture leads into a bursa seminalis (*B. s.*) provided with a chitinous appendage (*Ch. a.*). The single ovary (*Ov.*) lies at the hind end of the body nearly in the middle line; it is somewhat curved, and the eggs are progressively riper from behind forwards. In front of the ovary is a structure which may be called the receptaculum seminis (*R. s.*).

The pigmented eye-spots found in many Rhabdocœles are here absent, and there is no otolith.

In several respects this little creature differs from any known forms; its nearest allies appear to be found amongst the Mesostomidæ and Proboscidæ as defined by von Graff [2], but as it cannot well be referred to any known genus of either of these families I have found it necessary

to create a new genus for its reception under the name of Typhlorhynchus. The species may be called Typhlorhynchus nanus.

Habits.—Typhlorhynchus nanus, as already stated, is found on the body of Nephthys scolopendroides, to which it attaches itself by its hinder end. From Mr. Goodrich's figures (figs. 2 *a*—*c*) it appears to use its proboscis as a tactile organ. In no specimen that I have examined is there any food substance in the gut space, but in the protoplasm of the gut wall are numerous fine food granules. Its epizoic habit does not seem to have produced any marked degeneration of the organs of the body. The loss of the eye may be due to this, but a number of species belonging to the genus Mesostomum which are free-living (*e. g.* M. Cuenoti, recently described by Dörler [5]) are also without eyes.

The other known parasitic Rhabdocœles belong to the family Vorticidæ, and include a number of forms parasitic in Echinoderms, on the kidneys and gills of Molluscs, etc.

Method.—Mr. Goodrich obtained specimens of Typhlorhynchus by putting Nephthys scolopendroides into sea water with about 10 per cent. of alcohol (70 per cent.), when the parasite fell off in considerable numbers. No eggs were found. They were then treated with corrosive sublimate and acetic acid or with Lang's reagent. Those treated with the latter yield on the whole the best results in sections, the protoplasm being beautifully preserved. Those hardened with the former reagent have shrunk to some extent, but in them the gland cells and rhabdites stain more readily. I have examined a number of series of sections both transverse and longitudinal, as well as specimens mounted whole. For the sections I obtained excellent results with brazilin; I also employed the iron-hæmatoxylin method of staining. Whole preparations were stained with borax carmine.

Structure: Integument.—The body-wall is made up of a layer of ciliated epithelium lying upon a double muscle layer. The epidermis is equally ciliated over the whole surface of the body. A number of irregularly arranged

papillæ formed by the bulging out of the epidermis occur on the proboscis (fig. 5, *T.*), and some few at the hind end of the body. The flattening observed at the hind end of several specimens is undoubtedly connected with the mode of attachment observed by Mr. Goodrich.

The average thickness of the epidermis is 5 μ. No cell limits can be discerned in it. In sections of specimens preserved with Lang's reagent small clusters of nuclei, four or five in each cluster, are scattered at considerable intervals through the epidermis. The outer limit of the epidermis is seen as a delicate line, which under high power resolves itself into a row of exceedingly fine dots, recalling exactly the appearance figured by Böhmig for Monoophorum striatum, Böh.; whilst the clusters of nuclei suggest the "Tastkörperchen" of the same species (**3**, pl. xx, figs. 17—19), except that there is no break in the cilia above them. In the case of sections of specimens fixed with corrosive sublimate and acetic acid numbers of small deeply stained rhabdites are visible in the epidermis. Assuming that the clusters of nuclei referred to above are to be regarded as connected with sensory organs, the question arises as to the whereabouts of the true epithelial nuclei. The nuclei in the clusters are the only ones occurring in the epidermis so far as my sections show.

The basal membrane is thin, about 1 μ thick or rather less. The muscle layers consist of an outer circular and an inner longitudinal layer, evenly developed all over the body (fig. 7, *Cir.*, *Lon.*). Special sphincter muscles, derived apparently from the circular layer, lie round all the three openings in the body-wall (figs. 4—7, *Sp.*). But few gland-cells are developed in connection with the surface of the body. A few cells with granular deeply staining protoplasm lie here and there immediately under the muscle layers of the body-wall, and doubtlessly come into this category; they are more numerous in the proboscis than elsewhere (fig. 5, *Gl.*).

Parenchyma.—The space between the various organs of the body and the body-wall is occupied by the parenchyma,

This consists of a reticulum of delicate fibrillar protoplasm containing round finely granular nuclei; the protoplasm is without cell limits, and the nuclei are few and widely scattered. Most of the body organs, e.g. yolk glands, penis, etc., lie in perfectly definite spaces in this parenchyma, but in two cases, viz. the gut wall and the bursa seminalis, this is not so. The lining of the gut space consists of protoplasm without cell limits, of precisely the same character as that of the parenchyma, and it is not marked off from the latter in any way. The only characters which serve to distinguish the gut wall (endoderm) from the parenchyma are, firstly, the nuclei, which in the endoderm are oval, and contain coarse darkly staining chromatin granules (fig. 7, *Nuc.*), whilst those of the parenchyma, as stated above, are round and finely granular (fig. 7, *P. N.*); and secondly, the presence in the endoderm protoplasm of numbers of fine granules, which are probably food granules, but these only disappear gradually in passing from the endoderm to the parenchyma.

In the case of the bursa seminalis the protoplasm forming its walls, though denser and more hyaline than the general parenchyma protoplasm, nevertheless merges quite imperceptibly into it.

Owing to the spaciousness of the enteron and the size of the yolk glands in the middle regions of the body, the parenchyma in those regions is much reduced.

In the proboscis the parenchyma is densest immediately under the body-wall; below this it is spongy and scarcely distinguishable, especially towards the tip of the proboscis.

Alimentary Canal.—The mouth opens on the mid-ventral line just behind the constriction at the base of the proboscis. As already stated, there is a sphincter muscle arrangement around the mouth opening, developed from the muscles of the body-wall, most probably from the outer circular layer, but possibly from both; my sections do not bring this point out clearly.

The mouth opens into the pharyngeal pouch ("Pharyngealtasche," von Graff). This pouch is at first narrow, but as it passes dorsally it widens into a chamber of small size, into

which the lower part of the pharynx projects (fig. 3, *Ph. T.*, *Ph. T*$_1$.), so that the roof of the chamber is formed by the pharynx itself. The pouch agrees very closely with that figured by von Graff [2] for Mesostomum Ehrenbergii, and, as in the latter, it is provided with a few muscle-fibres attached to the walls at its widest part, running to the body-wall. Neither the epithelium lining the wider part of the pouch nor that on the exposed part of the pharynx is ciliated, the cilia only extend to the narrow part of the pouch. With this should be compared the condition found in Mesostomum Ehrenbergii, v. Graff, in which the pouch is ciliated throughout. In Mesostomum Cuenoti, recently described by Dörler [5], on the other hand, only the roof of the pouch, i.e. the projecting wall of the pharynx, is ciliated. The pharynx itself has its principal axis a little elongated, and running nearly dorsiventrally. It is pyriform, its narrow end being ventral and the broader dorsal. The larger size of the dorsal part is due to the greater size in that region of the pharyngeal cells (fig. 3, *Ph. C.*).

The pharynx conforms to the type called by von Graff "pharynx rosulatus," characterised by the numerous large gland cells which in sections appear as coarsely granular cells, and also by the arrangement of the muscle-fibres. The latter consist of a double outer layer, forming, as it were, a muscular capsule, and a double inner layer lying immediately under the epithelium lining the lumen of the pharynx. Between these two definite layers run numerous radial fibres (fig. 3, *R.M.*). The outer layer consists first of longitudinal fibres (*O.L.*),—that is to say, of fibres running parallel to the principal axis of the pharynx; and immediately below these, of stouter circular fibres (*O. Cir.*). The inner layer consists of a number of fine circular fibres (fig. 4, *I. c.*), lying immediately on the outside of the epithelial lining of the lumen (*Ph. E.*), and outside these of longitudinal fibres (fig. 3, *I. L.*), which like the inner circular fibres are but feebly developed. The radial muscles are most numerous in the ventral part of the pharynx.

The epithelium lining the lumen (*Ph. E.*) is very much reduced, excepting at the lower end of the pharynx, where it is continuous with the epithelium on the exposed surface. It is quite devoid of nuclei (cf. Mesostomum Cuenoti).

In addition to the intrinsic muscles of the pharynx a large number of fibres run from the body-wall to become attached to its anterior wall, apparently fusing with the outer longitudinal fibres of the pharynx itself. It is the insertion of these fibres into the body-wall which causes the constriction that cuts off the proboscis from the rest of the body (fig. 4, *A. M.*).

There is no well-marked œsophagus; a few unicellular glands lie in the neighbourhood of the upper end of the pharynx.

The gut is spacious; posteriorly it extends as far back as the level of the female aperture. That part of it running into the proboscis is best described as an anterior unpaired diverticulum (fig. 1, *A.d.*). This diverticulum is often occluded to a considerable extent by pseudopodial processes sent out by the endoderm, but can always be distinguished in transverse sections. The characters of the endoderm have been sufficiently described in dealing with the parenchyma.

Nervous System.—The brain lies in the proboscis at about its middle, and consists of a quantity of ganglion cells (fig. 5, *G.*) lying about a transversely elongated mass of "Punktsubstanz," apparently composed of exceedingly fine fibrillæ (fig. 5, *br.*).

The Punktsubstanz, or central mass, is divided into two lobes by a slight median constriction, and from each of the lobes a group of nerve-fibres runs outward for a short distance towards the wall of the proboscis, and then turns backwards (fig. 5, *N.*). A group of fibres also runs from the ganglion cells lying in front of the central mass to each lobe of the latter close to the middle line, and a similar group of fibres passes into the central mass from ganglion cells lying behind it. These posterior fibres do not form such compact groups as the anterior pair, and enter the central mass more laterally.

The ganglion cells stain very darkly, and appear to be bipolar; the nucleus is finely granular and rather large, and there is a small black nucleolus.

The arrangement of ganglion cells lying on the anterior side of the central mass is remarkable. On either side of the middle line a group of them extends forwards like a horn from the main body of ganglion cells, and curves slightly inwards at its anterior extremity, ending some distance from the tip of the snout. The cells constituting these two horns are identical in character with the other ganglion cells. Numerous nerve processes run forwards from them to the tip of the snout, others run down to join the groups of fibres entering the brain anteriorly (fig. 1, *H.*).

The tip of the proboscis then appears to have a very rich nerve supply, and we may conclude that the proboscis is the chief seat of the tactile sense. Possibly with this is correlated the presence on the proboscis of the papillæ already referred to, although such papillæ are not entirely confined to it.

Organs of Reproduction.

(a) Female.—The ovary is single, and lies at the hinder end of the body nearly in the middle line; it is short and somewhat curved (fig. 1, *Ov.*), its length is about ·12 mm., and it contains from twelve to fifteen eggs, which are progressively riper from behind forwards. The eggs are oblong, closely pressed against each other, and have large nuclei. Their protoplasm is finely granular. The nuclei have a deeply staining capsule; immediately below this a number of coarse, dark granules, and inside these a relatively clear space in which lies a large black nucleolus (fig. 8, *Ov.*). As already stated, the ovary lies in a space hollowed out in the parenchyma, and is surrounded by a protoplasmic membrane containing flattened nuclei.

In front of the ovary this membrane is apparently attached to a short funnel-shaped structure which ends blindly in the

parenchyma, and has its wider end next the ovary (fig. 8, *R. s.*). In the space enclosed by this body, which may be called the receptaculum seminis, lies a small mass composed of spermatozoa (fig. 8, *S.*), which are thus immediately in front of the ripest, most anterior egg.

There is a pair of unbranched yolk glands which extend from the level of the front end of ovary as far forward as the pharynx, lying close along the lateral wall of either side of the body in a cavity of the parenchyma, which here is not much developed.

These yolk glands are built up of elongated cells lying parallel to one another and closely pressed together, with their long axes roughly dorsiventral. Each cell has a nucleus at about its middle; each nucleus contains a nucleolus lying in a clear space in the centre of the nucleus, surrounded by a finely granular ring when seen in section. In each cell are two, three, or several small black refringent bodies, which tend to group themselves together in a ring. Amongst these black bodies are found small refringent yellow globules of yolk matter.

The female aperture is furnished with a sphincter muscle arrangement (fig. 7, *Sp.*), and opens into a small chamber (fig. 7, *B. s.*). The ciliated epidermis of the body-wall extends to the walls of this chamber. Into it the bursa seminalis (fig. 7, *B. s.*) opens dorsally through a narrow neck. Above the neck, which is quite short, the cavity is transversely widened, but narrow antero-posteriorly. Dorsally it extends to a point just below the front end of the ovary, but does not communicate with the latter directly. The cavity is bordered by a chitinoid lining substance which stains deeply; beyond this lining the walls are built up of clear hyaline protoplasm, which merges quite gradually with the protoplasm of the parenchyma. A small number of muscle-fibres lie in the walls of the bursa, running from the neighbourhood of the neck of the cavity to the body-wall, or in some cases to the capsule of the penis (fig. 7, *M.*). The hinder wall of the bursa at about its middle is produced to form a kind of spout

or short tube, which is blocked up by a small chitinous plug (*Ch. A.*). This latter agrees with the "Chitinanhang" described by von Graff for Hyporhynchus coronatus, v. G. [2], and with a similar organ found in many other forms.

Owing to the way in which the walls of the bursa seminalis merge into the parenchyma in whole preparations it is only possible to determine the position of the lumen. In sections some distinction, as pointed out above, can be drawn between the tissue immediately surrounding the lumen and the parenchyma proper. In no case that I have examined does the bursa seminalis contain spermatozoa.

I have found considerable difficulty in interpreting the funnel-shaped organ which I have called the receptaculum seminis; the explanation here put forward of this organ was suggested to me by an examination of a figure of Byrsophlebs Graffii (Jens.) in Jensen's work 'Turbellarier ved Norges Vestkyst' [1].

In Byrsophlebs Graffii the riper end of the single ovary is posterior, and immediately behind it lies an organ which Jensen calls the receptaculum seminis. This receptaculum opens to the exterior, and contains spermatozoa which do not, however, according to Jensen in his account of this species, reach it directly, but pass through the opening into a bursa copulatrix (the receptaculum and bursa having a common opening), and from the bursa travel along a long convoluted duct, called by him the ductus longus, into a receptaculum. Now it is evident that, so far as its position goes, the receptaculum bears the same relation to the ovary of Byrsophlebs Graffii, as does the funnel-shaped organ to the ovary of Typhlorhynchus nanus. Both, moreover, contain spermatozoa.

The organ called by Jensen bursa copulatrix would, then, be homologous with the organ which I here call the bursa seminalis. My reason for adhering to the latter name is that it is used by von Graff to designate a comparable organ in Hyporhynchus and other genera.

If, then, we may suppose that the receptaculum seminis in

Typhlorhynchus has lost its opening to the exterior, we can readily compare the female organs in this creature with those of Byrsophlebs. The spermatozoa may reach the receptaculum (funnel-shaped organ) by a duct similar to the ductus longus of the latter; such a duct would scarcely be discernible save in the living state and when full of spermatozoa.

It should be remarked that the walls of the bursa are much folded, so that the lumen is quite irregular.

(b) Male: Testes.—There is a pair of compact spherical testes, one on either side of the proboscis immediately behind the brain (fig. 5, *Te.*), each enclosed in a very delicate membrane, which often is hardly distinguishable. In every specimen that I have examined I have found apparently mature spermatozoa lying for the most part on the dorsal and anterior surface of either testis. The rest of the testis is composed of sperm mother-cells in various stages of development. I have not found it practicable to follow out the history of the development of the spermatozoa. The appearance of the cells composing the testes agrees very closely with that of the germ-cells of Plagiostoma Girardi figured by von Graff (l. c., Taf. xvi, figs. 11—14). I have also compared sections of the testes of Typhlorhynchus with some of Mesostomum tetragonum, O. Sch., and find there, too, a strong resemblance. Cells in a morula state are always present (fig. 5, *Mo.*). The position of the testes is hardly paralleled amongst the Mesostomidæ and Proboscidæ.

In Macrorhynchus Naegelii, as figured by von Graff (loc. cit., Taf. xi, fig. 7), they extend as far forward as the level of the brain and pharynx, but in no case do they lie in the retractile proboscis. In most Mesostomidæ and Proboscidæ the testes lie in the middle region of the body, and are continuous with the vesiculæ seminales. In Typhlorhynchus, however, I have not been able to find any communication between them, although the two vesiculæ always contain spermatozoa in my specimens. These vesiculæ (fig. 1, *V. s.*) are narrow tubes, with thin chitinous-looking walls, opening

close together into the penis at their posterior end, and each ending in a small swelling at their forward extremities. They have a total length of about ·15 mm.

The penis is about ·1 mm. long, backwardly directed, pyriform, with its apex curved ventrally. Close to the point at which the vesiculæ seminales open into it there open also a number of gland cells, which lie immediately ventral to the penis, and pour a secretion into it. The penis itself consists of an outer muscular capsule composed of muscle-fibres running parallel to the long axis of the penis (fig. 7, *Ex. M.*). There is an inner muscle layer also composed of a cylinder of longitudinal fibres, attached at one end to the outer capsule at its widest part, and by the other to the eversible part of the penis (fig. 7, *I. M.*). The outer capsule is continuous with the lining of the cavity immediately within the male aperture. The armature of the penis is very remarkable, and quite unlike that of any previously described form. Its appearance is well shown in Mr. Goodrich's figures (figs. 6*a*, *b*). When evaginated the penis is mushroom-shaped, with a convex head. From the margin of the disc of the head extend two lobes, one on either side [4]. From the centre of the head projects a long chitinous spine, whose proximal end is sharply crooked and embedded in the penis (fig. 6, *Ch.*). The convex surface of the head is covered with meridionally arranged rows of short, slender, slightly curved spines (*C. S.*). There appear to be some eighteen of these rows, each with ten or twelve spines.

The large central chitinous spine is tubular at its proximal end, but the tube distally appears to open out into a groove. This spine is an impregnating organ homologous with the "Chitinrohr" described by von Graff [2] for Proboscidæ and Mesostomidæ. The spermatozoa probably pass into its tube by an aperture at its proximal end (cf. Proxenetes gracilis, v. Gr. [2,. Taf. viii, fig. 12]). A few muscle-fibres are apparently attached to its base.

Affinities.—The character of the pharynx is sufficient to indicate that the Rhabdocœle under consideration is allied to

the families Mesostomidæ and Proboscidæ, and there are no features in the structure of Typhlorhynchus which forbid us to refer it to one or other of these families. Which of the two is to be selected depends chiefly on the importance attached to the proboscis. This in Typhlorhynchus differs sharply from a typical proboscis, such as is found in Macrorhynchus or Gyrator, but not so greatly from that of Pseudorhynchus. In all the genera referred by von Graff [2] to this family, however, the proboscis is retractile to some extent. Further, in none of them do the brain or the testes occupy a position similar to that found in Typhlorhynchus, and in Pseudorhynchus alone is the proboscis invaded by the gut space.

On the other hand, Byrsophlebs amongst the Mesostomids is characterised by the presence of two genital apertures, the male in front, the female behind—a character that only occurs in this genus and in Typhlorhynchus amongst the whole of the Rhabdocœla (*s. str.*), leaving out of account the Prorhynchidæ. Further, as I think I have shown, the female genital apparatus of Typhlorhynchus may be compared in detail with that of Byrsophlebs.

A bursa seminalis provided with a chitinous appendage very like that of Typhlorhynchus occurs in Hyporhynchus amongst the Proboscidæ and Proxenetes amongst the Mesostomids.

The penial apparatus, whilst differing greatly in detail from any of those figured for these families by von Graff, resembles them in a general way, especially in being provided with a chitinous tube or spout (Chitinrohr—cf. von Graff's figures of Hyporhynchus coronatus and Proxenetes gracilis).

It is, on the whole, I think, most convenient to place this new genus amongst the Proboscidæ in the neighbourhood of Pseudorhynchus. It differs sufficiently from other Proboscidæ to warrant the creation of a sub-family to receive it. In some respects, e. g. the female organs, it shows an approximation to Byrsophlebs, and may be regarded as to some extent

intermediate between the Mesostomidæ and Proboscidæ. It is particularly of interest as being the only member of either of these families that has adopted an epizoic habit.

The character of the parenchyma should be specially remarked. This, in the way in which it merges into the endoderm, shows a distinct approach to the condition found in the Alloiocœla.

The genus Typhlorhynchus may be defined briefly as follows:

Body provided with a non-retractile pre-oral lobe or proboscis. Gut not clearly separated from the parenchyma, provided anteriorly with a median diverticulum extending into the pre oral lobe. Pharynx rosulate, no genital atrium, male opening in front of female. Penis (when evaginated) with meridionally arranged rows of spines, and in addition a long chitinoid tube. The single pair of testes lie in the pre-oral lobe; ovary single, at hind end of body; yolk glands paired. Accessory female organs consist of—(1) a bursa seminalis opening to exterior by the female aperture; (2) a receptaculum seminis.

In conclusion, I wish to thank Dr. Gamble very sincerely for the kind way in which he has assisted and advised me in preparing this account.

Literature.

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EXPLANATION OF PLATE 35,

Illustrating Mr. F. F. Laidlaw's paper "On Typhlorhynchus nanus.

Fig. 1.—Typhlorhynchus nanus, diagrammatic, seen from above. × 90. *Pr.* Pre-oral lobe, snout, or proboscis. *M.* Mouth. *Ph.* Pharynx. *En.* Gut space. *A. d.* Anterior gut diverticulum. *Br.* Brain. *H.* Horn-shaped process. *Te.* Testis. *Pe.* Penis. *Gl.* Glands opening into the penis. Gl_1. Glands lying about the male aperture. ♂. Male aperture. *V. s.* Vesicula seminalis. *Ov.* Ovary. *R. s.* Receptaculum seminis. *B. s.* Bursa seminalis. *Ch. a.* Chitinous appendage. *Y. gl.* Yolk gland. ♀. Female aperture.

Fig. 2.—Various attitudes assumed in life. × about 10 times.

Fig. 3.—Long. sec. through the pharynx. × 400. *Ph. c.* Pharynx cells. *O. L.* Outer longitudinal muscles of pharynx. *O. Cir.* Outer circular muscles, and *I. L.*, inner longitudinal muscles of the same. *Ph. E.* Epithelium lining the lumen of the pharynx. *Ph. T.* Pharyngeal pouch. $Ph.\ T_1$. Narrow part of pharyngeal pouch. *R. M.* Radial muscles of pharynx. (The inner circular muscles are seen as a row of dots immediately to the inside of the inner longitudinal fibres.) *Sp.* Sphincter muscle of the "mouth" aperture. *A. M.* Muscles running from the anterior side of the pharynx to the body-wall. *Ex. M.* Other extrinsic muscles of the pharynx.

Fig. 4.—Trans. sec. through the pharynx region showing the gut diverticulum (*A. d.*). *I. c.* Inner circular muscles of the pharynx. Other lettering as in Fig. 4.

Fig. 5.—Horizontal section through the pre-oral lobe. *G.* Ganglion cells. *Gl.* Integumentary gland cells. *Mo.* Cells in morula stage in testis. *N.* Nerve. Other lettering as in Fig. 1.

Fig. 6 *a*.—Penial armature closed.

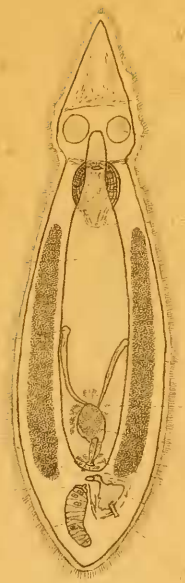
Fig. 6 *b*.—The same evaginated, "much enlarged, drawn from life." *Ch.* Chitinous tube. *C. S.* Chitinous spines. *L.* Lobes.

Fig. 7.—Long. sec. through the penis and bursa seminalis (drawn from two sections and combined). *Cir.* Circular muscle-fibres of body-wall. *Lon.* Longitudinal fibres of body-wall. *En.* Endoderm. *Ex. M.* External muscular capsule of the penis. *I. M.* Inner muscular layer of the same. *M.* Muscle-fibres. *Ar.* Penial armature. *Sp.* Sphincter muscle-fibres of female aperture. *B. s.* Chamber into which the bursa seminalis opens. $B.\ s_1$.

Bursa seminalis. *Nuc.* Endoderm nucleus. *P. N.* Nucleus of parenchyma. Other lettering as in Fig. 1.

Fig. 8.—Optical section through the bursa seminalis, receptaculum seminis, and ovary of a specimen mounted whole. *Ov.* Ovum showing the large nucleus. *S.* Mass of spermatozoa in the receptaculum. Other lettering as in Fig. 1.

(The position of the "month opening" is drawn rather too far back in Fig. 1.)



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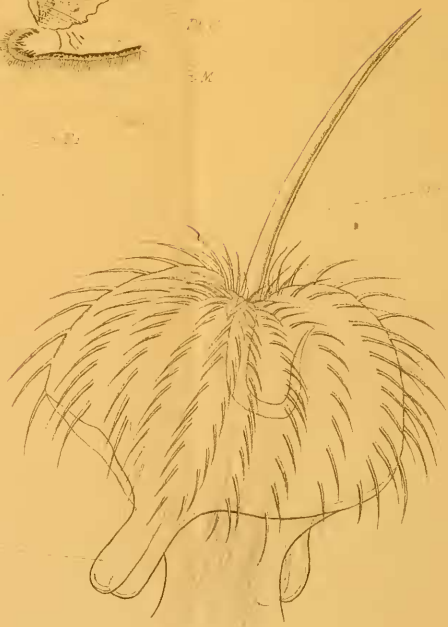

6b

5.

A. Smith, Lith. London